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This issue contains articles on the following subjects: 1.Warnings in Health Care; 2.Using a General Theory of Behavior (GTB) to Predict the Effects of Suppressive Fires; 3.Information Visualization: The Next Frontier; 4.Modelling the Effects of Respirator Mask Design on Wearer Performance

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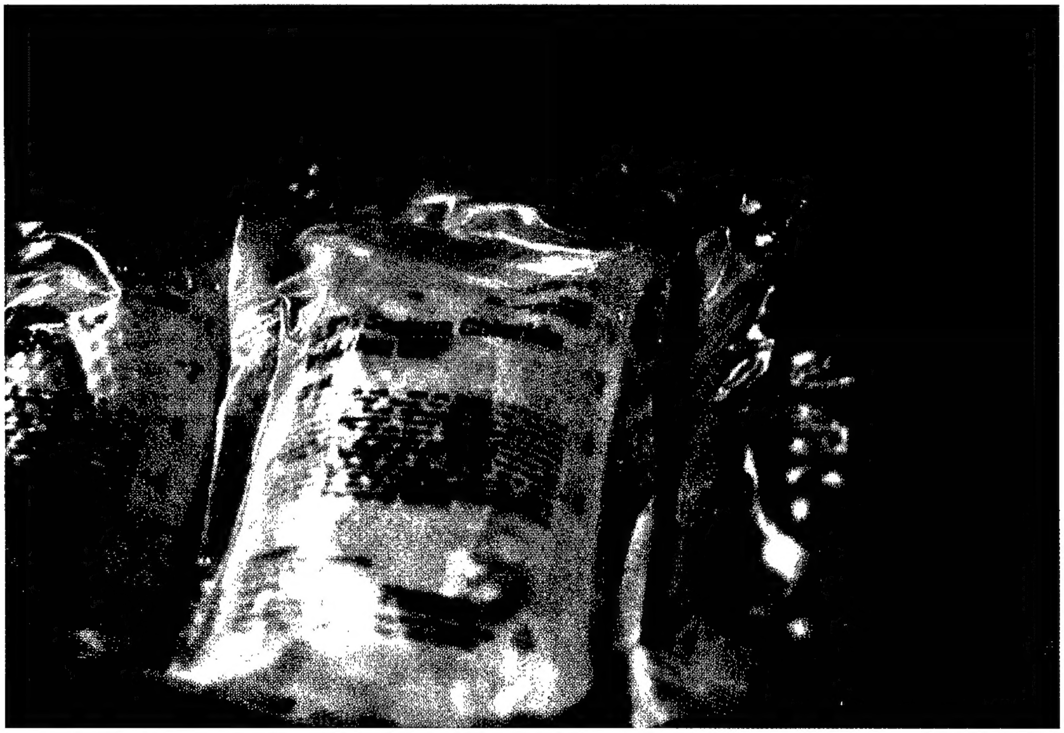

Figure 1. Similarly labeled products result in the potential for error and adverse outcome.

Warnings in Health Care

Marilyn Sue Bogner, Mathew B. Weinger, Kenneth R. Laughery, Ellen C. Haas, & Dennis O. Admunson

Human factors professionals have studied warnings in a variety of contexts from industrial signs to liquor bottles, from phrasing of messages to highlighting techniques. Warnings in health care are important especially in reducing the likelihood of error because of the potential for onerous outcomes (Bogner, 1994). For example, the packaging of some medical products is so similar that it induces error. For the products in Figure 1, if potassium were administered when saline (sodium chloride) was intended, or if saline with dextrose instead of saline alone were administered to a diabetic, there would be serious or fatal consequences. As subtle a warning as color-coding would reduce the likelihood of error. Despite this, warnings in health care have received relatively little consideration from the human factors community. The following discussion describes two categories of health-related warnings: how a drug should be taken or a medical device used, and warnings emitted by a medical device that indicate an abnormal condition of the device or the patient.

Regarding the use of a drug or medical device, the target audience consists of users who vary in experience, general competence, and technical expertise. Physicians, nurses, and pharmacists receive warnings from pharmaceutical companies and manufacturers of medical devices; they provide warning information to patients as well as the general public. Differences in target audience characteristics have implications for how warnings are designed and communicated, and influence the content, format, and mode of presentation of those communications for a variety of products.

The number and variety of over-the-counter (OTC) products are increasing. Those products which are obtained without prescription and often with

continued on next page

in this issue:

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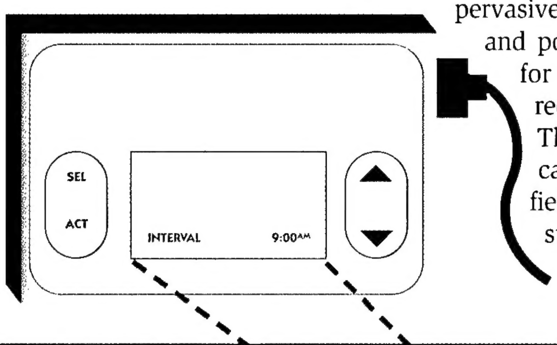
continued from previous page

guidance only from advertising typically are used to treat health problems that are not severe or life threatening. Not all OTC medications are for everyone and may have significant risks. Despite the pervasiveness of those products and possible risks, warnings for OTC products have received little attention. This particularly is the case for products classified as vitamins or food supplements such as St. John's Wort which are subject to relatively lax labeling and warning rules.

The search for information about use and warnings for OTC products can be frustrating. Often the instructions and warnings are vague or difficult for the typical user to read. When people examine a package insert, the folded piece of paper that accompanies most OTC products, they are confronted with printing that requires a magnifying glass to be read. Furthermore, the information provided about the conditions under which the product should not be taken and its possible side-effects often is confusing.

The current proliferation of direct-to-consumer advertising of prescription medications in the media often does not provide obvious warnings of potentially toxic interactions with other medications or foods. Uninformed consumers may insist on and receive products they presume to be safe and not attend to information provided, with potentially disastrous results.

Warnings emitted by medical equipment are important to more than health care professionals. Home medical equipment is one of the fastest growing industries in the country; warnings can be critically important for safe use in the home as well as in health care facilities. When a medical device malfunctions or a patient's vital signs change to indicate a deteriorating condition, it is reasonable to expect that a warning alarm will occur. Such alarms, however, are not commonplace and when they do exist, may not be effective.



Cause of Alarm	Visual Display	Audio Alarm
Pump Operation Suspended *	-S- Time	4 beeps
Pump in Storage Mode *		None
Low Battery Alarm	L.O.E. Time	2 beeps
Depleted Battery Alarm *	L.O.P. Time	4 beeps/minute
High Pressure Alarm *	HP Time	4 beeps/minute
Electronic or System Error Alarm *	E4 Time	4 beeps/minute
Pump recovered from beeps/ minute System Error for Delivery Mode Changed Alarm	E01 Time	4 beeps/minute

* Medication delivery stopped

Figure 2. Causes of alarm, visual displays, and audio alarms for a credit-card-size infusion pump.

Warning alarms are particularly important in technologically sophisticated medical equipment. An example of this is a credit-card-size infusion pump (a computer-chip-based device that is programmed to deliver medication at specific intervals through a needle or catheter in the patient) used in home care (Obradovich & Woods, 1996). Errors can occur easily when the user stops the pump to change the needle. Because errors may alter the functioning of the pump and result in inappropriate and damaging infusion of medication, the device has a series of warning alarms.

As can be seen in Figure 2, auditory warning alarm time intervals vary widely across the causes for alarm in the infusion pump; however four different problems have the same auditory alarm. Without differentiation, there is no way to determine from the alarm which of the four warnings is indicated. A redundant visual warning is provided on the pump's display; however, the credit-card size of the pump and the correspondingly small display provide a visual warning so small that it alone may not attract attention. The cue to draw the users' attention to the display should be the auditory alarm, but to do that, the alarm must be heard. The pump operates in the home and other environments in which noise may mask the alarm sound. These issues are not unique to the specific miniature pump discussed; rather they underscore the finding that the existence of alarms in medical devices does not guarantee their usefulness.

Nowhere in clinical care is medical sophistication and data overload more concentrated than in the intensive-care unit (ICU) and the operating room (OR). These complex, high-intensity, high-anxiety environments are notorious for the number and variety of medical devices, monitors, and life-support equipment present. Warnings for clinicians in such critical care settings predominantly are auditory alarms accompanied by visual information that indicates changes in the patient's condition. Auditory, visual, and tactile sensations such as those conveying warnings, can quickly overwhelm stressed and fatigued care providers. Misinterpretation or insensitivity to electronic warnings is ubiquitous. Indeed, alarms can impede task performance by health care professionals as well as be ineffectual in providing warnings.

In the acute care environment, the need to incorporate warnings into patient monitoring systems stems from several factors: the number of variables to be monitored has increased tremendously; equipment used to collect and display such variables has become technologically sophisticated; and given the complexity of the critical care tasks and their attendant stresses, the clinician without machine assis-

tance is unlikely to be able to detect all out-of-range variables or conditions. If clinical displays were easy to comprehend, presented only relevant information, and displayed the required information in one location, then perhaps alarms would be not be so important (Beneken & van der Aa, 1989).

The objective of any warning system should be to optimize the probability of the successful resolution of the problem at hand. The typical high-noise levels and often sub-optimal physical orientation of devices in the ICU and OR can impede alarm detection. Some alarm tones are distracting, induce unnecessary stress, and often elicit a response simply to make it stop. When the source of an alarm cannot be identified, the alarm becomes extremely distracting and tends to exacerbate a potentially difficult clinical situation. Problems may occur from incomplete or haphazard integration of devices and their accompanying alarms. Existing alarm standards have had only a modest impact. In addition, the incidence of false alarms continues to be high despite the implementation of integrated monitors. Block and Schaaf (1996) found that about one quarter of auditory alarms were spurious while only 23 percent represented actual potential patient risk.

The recent implementation of fully integrated anesthesia workstations has not adequately addressed existing problems and has created new ones. In situations where each discrete monitor had its own warning alarm, often with a unique sound, it was possible to localize and identify the nature of the alarm by the sound alone. With current integrated alarm systems, it is necessary to look at the central video display and in the case of multiple, concurrent alarms, mentally sort out and prioritize the active alarms. This is a problem because clinicians can't always look up for visual information due to the nature of many procedures. Little useful information is received from standardized auditory alarms because they are not readily distinguishable. The clinically most important alarm must be indicated first with less important alarms being suppressed during the annunciation of the higher priority alarm. Such systems must be flexible enough to permit expansion with new technological and medical advances. Medical devices that provide warning alarm thresholds based on each patient's evolving condition could markedly reduce the stress and workload on the clinician, and reduce the likelihood of error as well as the incidence of false alarms.

Medical environments such as hospital critical care units and many home care situations are demanding settings for auditory warnings. Individuals providing care under high-workload conditions, and often under noisy conditions, must interpret several auditory warnings that may be generated simultaneously. When designed appropriately, auditory warnings can improve performance and reduce the likelihood of error; however, researchers have found that many hospital environments contain too many auditory alarms to be remembered, some alarms are so similar they can be confused, and alarms can mask one another or be masked by the sound of other equipment. Unfortunately, auditory alarms often do not communicate the urgency of the situation.

The preceding discussion points to many targets for human factors considerations, both with warnings related to drug and medical device use as well as alarms emitted by medical devices. When effectively addressed, the results will benefit both the lay population and health-care providers. The issues described are not unique to health care; rather they represent variations on the common theme of warnings across a number of domains. Therefore, findings from research on visual and auditory warnings in military systems, aviation, and nuclear power may be useful in addressing health-care concerns if not directly, then by pointing to potentially fruitful activities. Now is the time for the human factors community to explore these possibilities. ■

References

Beneken, J. E. W., & van der Aa, J. J. (1989). Alarms and their limits in monitoring. *Journal of Clinical Monitoring, 5*, 205-210.

Block, F. E. J., & Schaaf, C. (1996). Auditory alarms during anesthesia monitoring with an integrated monitoring system. *International Journal of Clinical Monitor Computing, 13*, 81-84.

Bogner, M. S. (Ed.). (1994). *Human error in medicine*. Mahwah, NJ: Erlbaum.

Obradovich, J. H., & Woods, D. D. (1996). Users as designers: How people cope with poor HCI (human-computer interface) design in computer-based medical devices. *Human Factors, 38* (4), 574-593.

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Using a General Theory of Behavior (GTB) to Predict the Effects of Suppressive Fires

a column by
Michael Fineberg

Computerized simulation-based battlefield exercises typically consist of synthetic combatants operated and controlled by manned and unmanned systems. To recreate accurate and realistic scenarios within the computer-generated environment, algorithms are required that model the effects present in live and actual battle situations. Extensive time and effort are spent on modeling the weapon characteristics and their performance capabilities. Military tactics and doctrine also are modeled to guide the actions that take place under various conditions presented to the synthetic entity. The next step, modeling how the human performs, has proven to be quite difficult. It is my contention that the theory reported in the last issue of *Gateway* may help to resolve this issue.

A theory of behavior is only as good as its ability to predict those behaviors in special cases. To test the General Theory of Behavior (GTB), Fineberg, McClellan, and Peters (1996) used the theory to predict the effects of suppressive fires on dismounted infantry (DI) behavior. Suppressive fire was selected because "there is probably no obscurity of combat requiring clarification and understanding more urgently than that of suppression" (Dupuy, 1987). This assertion is supported by battlefield data and anecdotal reports suggesting that the attrition aspect (casualties typically < 10%) of combat power alone does not determine battle outcome (Hughes, 1995). The phenomenon of suppression has been most recently defined (Hughes, 1995) as "a non-lethal decrement in enemy combat performance from firepower that disappears when the battle is over."

Suppressive Fire Sources

Direct Fire Weapons

- Small arms
- Machine guns
- Tank mounted
- Anti-tank weapons
- Characteristics
  - Small area effect
  - Hit or miss
  - Point accuracy
  - Lower fear factor

Indirect Fire Weapons

- Artillery
- Air strike
- Characteristics
  - Wide area effect
  - Collateral damage
  - Higher fear factor

→

Suppressive Fire Signatures

Stimuli	Variables
Visual	Duration
• Flash	
• Smoke	Magnitude
• Debris	
• Wounds	Number
Aural	Frequency
• Bang	
• Whine	Proximity
• Whiz	
• Ricochet	Uncertainty
• Screams	
	Pattern
Tactile	
• Heat	
• Pressure	
• Debris	
• Wind	

Table 1. Sources and Signatures of Suppressive Fire

Results From a State-of-the-art Review

The effects of suppression have long been noted. Sun Tsu implied that the best battle is the one you don't fight, while an unnamed Union general, when told that his artillery bombardment was off target, was quoted as saying, "Damn the effect! It's the sound I want!" If we can quantify the relationship between the parameters of suppressive fires and the behaviors of the troops near "ground zero," suppression indeed may be modeled in synthetic forces of the future. Our first step in quantifying those relationships was to characterize and operationally define the phenomena associated with suppressive fire (Table 1).

The stimuli and associated variables of suppression manifest themselves in changes in the behavior of combatants. These changes are mediated by constructs including radius of effect, troop deployment and posture, intensity of bombardment, and several miscellaneous variables (USAFAS, 1979). Radius of effect can be expressed as: $R_m = 69.3(W^{hekg})^{1/2}$ where R is the radius in meters, 69.3 is a constant determined by a least-squares regression, and W is the weight of high explosives in kilograms. This equation can be used to calculate equivalent areas for a given level of suppression. The area in which half of those under fire will not return fire ($P_s = .5$) is 2,160 m^2 for 5 rounds of 50-caliber shells, 35,300 m^2 for one 155-mm shell, and 211,800 m^2 for one 8-inch shell.

With respect to the effects of deployment and posture on area of suppression, we find that an artillery shell landing within a circle of 1000 to 2000 m^2 around their position suppresses troops in the open. Troops in emplacements are not affected by suppression unless a shell lands within a circle of 300 to 500 m^2, and troops in armored personnel carriers (APCs) are not suppressed until the fire is within a circle of 120 to 140 m^2. Suppression also can be measured in terms of simple proximity of the burst to one's own position. Table 2 shows proximity in meters for several types of weapons relative to a desired level of suppression.

Another predictor of suppression is the volume or intensity of fire. Table 3 indicates the number of shells per minute for various weapons necessary to achieve suppression at two probabilities.

Many other intervening variables have been noted in the studies we reviewed. For example, random distribution of fire throughout the target area is more suppressive than systematic patterns of fire. Those who are knowledgeable about the lethality of weapons are 40 percent more suppressed than those who are not. Soldiers operating alone are from 43 percent to 115 percent more suppressed than those who are with others. Those in a frontal parapet foxhole are 62 percent less suppressed than those in a conventional foxhole. The most suppressive fires occurred directly in front of the soldier, the least suppressive occurred directly behind him (USAFAS, 1979).

Constructing a Suppression-sensitive Dismounted Infantry (DI) Team

Using the GTB to derive mathematical relationships and the parameters of suppressive fires from the literature as source terms, we began the process of representing the psychological phenomenon of suppression in Modular Semi-Automated Forces (ModSAF). We chose ModSAF 2.1 as the developmental tool for suppression-sensitive DI because of its capability to create and control unmanned entities in the Distributed Inter-active Simulation (DIS) environment. The suppression-sensitive infantry team was constructed within a version of ModSAF 2.1 modified with indirect fire routines. Tune in same time, same channel for the next installment of *Gateway*. I'll report on the methods used to model and implement the relationships underlying suppression-sensitive performance into synthetic DI thus providing a test for the GTB.

As always, your comments are most welcome. I look forward to the scientific discourse that may be prompted by my ramblings. Please call me at (703) 289-5120 or e-mail me at fineberg_michael @bah.com. ■

References

Directorate of Combat Developments. (1979). *The Fort Sill Fire Suppression Symposium Report*. Fort Sill, OK: USA Field Artillery School.

Dupuy, T. N. (1987). *Understanding war: History and theory of combat*. New York: Paragon House.

Fineberg, M. L., McClellan, G. E., & Peters, S. D. (1996). Sensitizing synthetic forces to suppression on the virtual battlefield. In *Proceedings of the Sixth Conference on Computer Generated Forces and Behavioral Representation*. Orlando, FL.

Hughes, Wayne P., Jr. (1995). *Two Effects of Firepower: Attrition and Suppression*. Monterey, CA: Department of Operations Research, Naval Postgraduate School.

P_{supp} / Weapon	.5	.9
M-16	88-128	293-413
M-2	23-25	75-100
105 How	5-10	15-25
155 How	4-10	12-25
8 in How	2-5	5-10

Table 2. Proximity Necessary to Result in Two Levels of Suppression

P_{supp} / Weapon	.5	.9
M-16	1-3	
M-2	24-26	5-8
105 How	51-118	21-55
155 How	104-144	63-77
8 in How	257-392	126-169

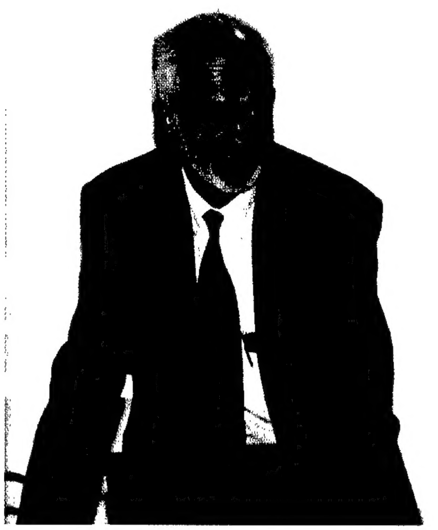
Table 3. Rounds per Minute for Two Levels of Suppression

Michael Fineberg, Ph.D., is the Chief Scientist for the CSERIAC Program Office.

Information Visualization: The Next Frontier

Nahum Gershon

Editor's note: Following is a synopsis of a presentation by Dr. Nahum Gershon, Principal Scientist with The MITRE Corporation, Washington, DC. He was the fourth speaker in the 1997 Human-Technology Integration Colloquium Series sponsored by the Armstrong Laboratory Human Engineering Division. Please note that the Armstrong Laboratory is now part of the Air Force Research Laboratory. This synopsis was prepared by Michael Reynolds, Senior Human Factors Engineer, CSERIAC Program Office. JAL


Dr. Nahum Gershon, The Mitre Corporation

The lecture on information visualization began with the National Science Foundation's original definition (circa 1988) of visualization as "a method of computing." However, this definition does not consider the human component and the speaker contends that visualization is more. Visualization is a process of transforming data, information, and human experiences and emotions into a visual form enabling the user to observe, understand, make sense, experience, and feel. It is clearly more than just "pretty pictures;" it involves interactive graphics and imaging techniques that must meet the needs of the human visual system and the task at hand.

The first application of visualization was in science where the data were primarily spatial in nature and had known metaphors, for example, an earth-surface temperature drawing where data were mapped to geographical locations. Here, the amount of data was relatively small and came in slow streams which provided ample time for analysis. In addition, the audience for this data was a relatively small, uniform group with extensive education and experience.

Visualization of everyday information, however, typically involves massive quantities of non-spatial data arriving in fast, flowing streams that require quick decision making. In addition, the uncertainty associated with these data is more complex and must be expressed on a number of dimensions, including time, quality, age, intent, trend, and path. As an example of an information visualization problem, consider the hierarchical structure of an organization or the results of a search on the World-Wide Web. The visualization goal is to map this information onto a physical 2-dimensional space. It is a challenging task to create a spatial metaphor to completely and adequately express the information within such a hierarchical structure.

Generally, the information to be visualized is in the form of text, lists, and numbers which make information extraction by computer difficult. Because the information is arriving so fast and from so many different sources, there is little time for thorough examination before a decision must be made. In addition, the audience for such general information is in the billions and is characterized by diverse capabilities, education, and needs. Consideration of these parameters only adds to the challenge of coherent information presentation.

Information visualization faces several challenges, including the fact that visualization practitioners often lack knowledge and training in visual communication; they may be well-versed in computer-related skills, but may not have intensive understanding regarding the use of color and design.

Another challenge involves the development of new representational methods. For example, using the page metaphor on the World-Wide Web is ineffective. Information must now be displayed in a new, visually exciting way while considering the issues of content and effectiveness.

The visualization practitioner must create visualizations that enhance creative thinking and human-information interaction (HII). New and emerging technologies exist to assist the practitioner. For example, with the use of JAVA and VRML, users could be allowed to customize the visualization of

incoming data to suit their specific needs. In addition, there will soon be 3-dimensional chips within the common desktop computer that will allow practitioners to create and use complex 3-dimensional visualizations more readily.

The media of visual computing and display are new. Information is now displayed on a computer screen rather than paper and to take full advantage of this, these new media need to be better understood. This is a process that will take many years and efforts to become fully mature.

Some of the positive aspects of using computer screens include the fact that information presentation can be changed quickly (e.g., color, representation, etc.), animation can be introduced, hyperlinks can be created, and a certain amount of interactivity is possible (e.g., activating/de-activating, highlighting, etc.).

Some of the negative aspects of using computer screens for information presentation are that information is presented at a low resolution and that most people consider it easier to read a traditional paper book than a computer screen. Interestingly, it is the development of computer technology that has improved the process of printing books, hence, maintaining the favored status of printed books over electronic documents. ■

Calling All Authors!

Papers Now Being Accepted for the 70th Annual Shock & Vibration Symposium

SAVIAC
Attn: Sue Damanda
2231 Crystal Drive
Suite 711
Arlington, VA 22202

Tel: (703) 412-7712
Fax: (703) 412-7500
email: damanda_sue@bah.com

The Shock and Vibration Information Analysis Center (SAVIAC) is sponsoring the 70th Annual Shock and Vibration Symposium from November 15 to 19, 1999, and needs presenters. The symposium will be held at the Crowne Plaza Pyramid, 5151 San Francisco Road NE, Albuquerque, New Mexico, and will feature government—Defense Threat Reduction Agency (DTRA) and Sandia National Laboratories—and industry—HI-TEST Laboratories—representatives.

Since 1929 the Shock and Vibration Symposium has provided a forum for government, industry, and academia to exchange information on current work and new developments in the structural dynamic behavior of air, sea, space, and ground vehicles and structures. For this year's symposium, presentations in any of the following subject areas are welcome—

- Active vibration control
- Ballistic shock
- Biodynamics
- Blast design and protection
- Computational structural dynamics
- Crash dynamics
- Damage identification
- Dynamic analysis methods
- Dynamic measurement
- Dynamic scale modeling
- Dynamic testing
- Shock and vibration environmental databases
- Finite element analysis
- Fluid-structure interaction
- Ground shock
- Seismic shock
- Impact/penetration mechanics
- Isolation systems
- Live-fire testing
- Machinery diagnostics and vibration
- Material dynamic properties
- Modal analysis and testing
- Pyrotechnic shock
- Shock characterization, hardening, and simulation methods
- Shock and vibration specifications and standards
- Underwater shock testing
- Vibroacoustics

Two categories of presentations—full papers to be published (CD-ROM only) in the Symposium Proceedings and short discussion topics consisting only of viewgraphs—will be accepted based on their abstracts. All abstracts are due by June 1, 1999 to—(see inset)

The Program Committee will review the abstracts the week of June 14, 1999, and authors will be notified of acceptance by July 2, 1999. Papers to be included in the Symposium Proceedings are due December 17, 1999. For abstract submittal, registration, and other symposium information, interested authors are invited to visit the SAVIAC website at http://saviac.xservices.com and to consult future issues of the SAVIAC *Current Awareness* newsletter.

calendar

feb

Santa Fe, NM, USA, February 9-12, 1999
Vision Science and Its Applications
Contact the Optical Society of America, 2010 Massachusetts Avenue, NW, Washington, DC 20036-1023, USA. Tel: (202) 416-6100, Fax: (202) 416-6130, email: confserv@osa.org, http://www.osa.org

Atlanta, GA, USA, February 25-27, 1999
24th Annual National Hearing Conservation Association Conference
Contact NHCA, 9101 Kenyon Avenue, Suite 3000, Denver, CO 80237, USA. Tel: (303) 224-9022, Fax: (303) 770-1812, email: ncha@gwami.com

mar

Baltimore, MD, USA, March 11-13, 1999
APA-NIOSH 4th Interdisciplinary Conference on Work, Stress, and Health
Contact the American Psychological Association, 750 First Street, NE, Washington, DC 20002-4242, USA. Tel: (202) 336-6033, Fax: (202) 336-6117, email: work-stress-conf@apa.org, http://www.apa.org/pi/niosh.html

Amsterdam, Netherlands, March 14-16, 1999
3rd European International Conference on Design Management
Contact Design Management Institute, 29 Temple Place, Boston, MA 02111-1350, USA. Tel: (616) 338-6380, Fax: (617) 338-6570, email: dmistaff@dmi.org, http://www.dmi.org

apr

Orlando, FL, USA, April 5-9, 1999
Cockpit Displays VI
Contact Darrel Hopper, AFRL/HECV, Bldg 248, 2255 H Street, Wright-Patterson AFB, OH 45433-7022, USA. Tel: (937) 255-8822, Fax: (937) 255-8366, email: dhopper@falcon.al.wpafb.af.mil,http://www.spie.org/info/or

Yellow Springs, OH, USA, April 20-22, 1999
Short Course in Anthropometric Measurement
Contact Anthropology Research Project, PO Box 307, Yellow Springs, OH 45387, USA. Tel: (937) 767-7226, Fax: (937) 767-7226, http://www.arp-online.com

may

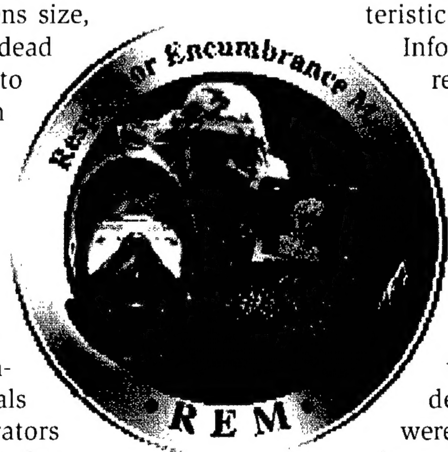
Columbus, OH, USA, May 2-6, 1999
10th International Symposium on Aviation Psychology
Contact Richard Jensen, Aviation & Industrial Engineering, Ohio State University, 164 West 19th Avenue, Columbus, OH 43210, USA. Tel: (614) 292-8378, Fax: (614) 292-1014, email: rjensen@magnus.acs.ohio-state.edu

Modeling the Effects of Respirator Mask Design on Wearer Performance:

Phase I Concept/Initial Development

David M. Caretti, David F. Wourms, & Kaushik Ghosh

The US Army Edgewood Research, Development and Engineering Center (ERDEC), through the Battelle Memorial Institute, is developing an engineering tool that allows mask designers to relate physical mask design parameters (MDPs) such as lens size, filter media, or dead space volume, to their influences on human performance. The PC-based tool, called the Respirator Encumbrance Model (REM), will be used to predict the performance of individuals wearing respirators based on the design characteristics of the mask and the requirements of selected military tasks. This article details progress made during Phase I of the project and briefly describes Phase II work in progress.



Phase I

Identifying a Need

The primary respirator design focus is to maximize wearer protection from airborne contaminants while minimizing the design's impact on user performance. While design approaches for increased protection are well researched and documented, there is currently no easy way to incorporate human performance information into the design process. For this reason, ERDEC initiated the development of this engineering design tool to minimize much of the guesswork, cost, and hours currently expended determining the effects of new mask designs on wearer performance.

Information Acquisition

An extensive review of protective equipment design information was undertaken to identify the relationship between respirator mask characteristics and human performance. Information sources were assessed for relevancy based on (1) applicability to the REM project (e.g., sources documenting the degraded vision of soldiers wearing masks were rated high while sources discussing the effects of mask wear on soldier's sleep were rated low) and (2) type of data presented (e.g., sources containing quantitative test data or derived performance algorithms were rated high and sources containing qualitative data that could not be used to develop performance algorithms were rated low). All relevant resources were subsequently entered into a bibliographic database.

National Institute of Occupational Safety and Health (NIOSH), Occupational Safety and Health Association (OSHA), and commercial sources were also contacted. Results indicated a heavy emphasis on the protection levels required in various environments as well as issues of filtration efficiency and prevention of medical complications.

Developing the REM Database Structure

Following bibliographic database development, ERDEC and Battelle created a high-level schematic of the REM to map the potential flow of information (see Figure 1). The information flow was adapted from the Operational Requirement-based Casualty Assessment (ORCA) model developed for the US Army Research Laboratory, Survivability and Lethality Analysis Directorate, and the Crew Casualty Working Group of the Joint Technical Coordinating Groups for Munitions Effectiveness and Aircraft Survivability. The ORCA model pro-

vides a methodology for assessing operational capabilities of soldiers who have been injured by various munitions and theoretical chemical agent exposures. ERDEC and Battelle have determined that the baseline architecture of the ORCA model could serve as a guide for REM development, thus allowing the REM to calculate performance degradation as a result of wearing variously configured respirator equipment.

Two lists are also important in the description of the model. The first is a set of MDPs that collectively define mask characteristics having a direct influence on human performance. Examples include lens shape and area; voicemitter location; inlet and outlet valve area, shape, and material; and hood material and thickness.

The second list details psychological and physiological factors of human performance that may be influenced by respirator wear. The ORCA model was revisited to determine if its established list of human capabilities could be applied to the realm of respirator wear. Of the 24 capabilities listed in ORCA, 15 were believed to be directly relevant to the REM. In addition, five capabilities related to mask wear were believed to be missing and were subsequently added to create a list of 20 REM capabilities. Sample REM capabilities include inhalation and exhalation resistance, respirator dead-space volume, thermal burden, and comfort.

Initially, the REM is limited to male infantry soldiers with good eyesight wearing the most widely issued size mask. The selected tasks will be performed immediately upon donning the mask, and degradation in performance will be attributed to mask wear and not to a breakdown in respiratory protection.

Phase II

Phase II work has begun to implement a working REM by populating the established architecture (based on Microsoft Access 97) with empirical data. This phase involves processing the knowledge gathered into computer-coded algorithms for predictions of performance. In addition, we will be expanding the task lists to include selected military occupations from the other services and refining the database structure and the user interface to streamline data entry requirements. ■

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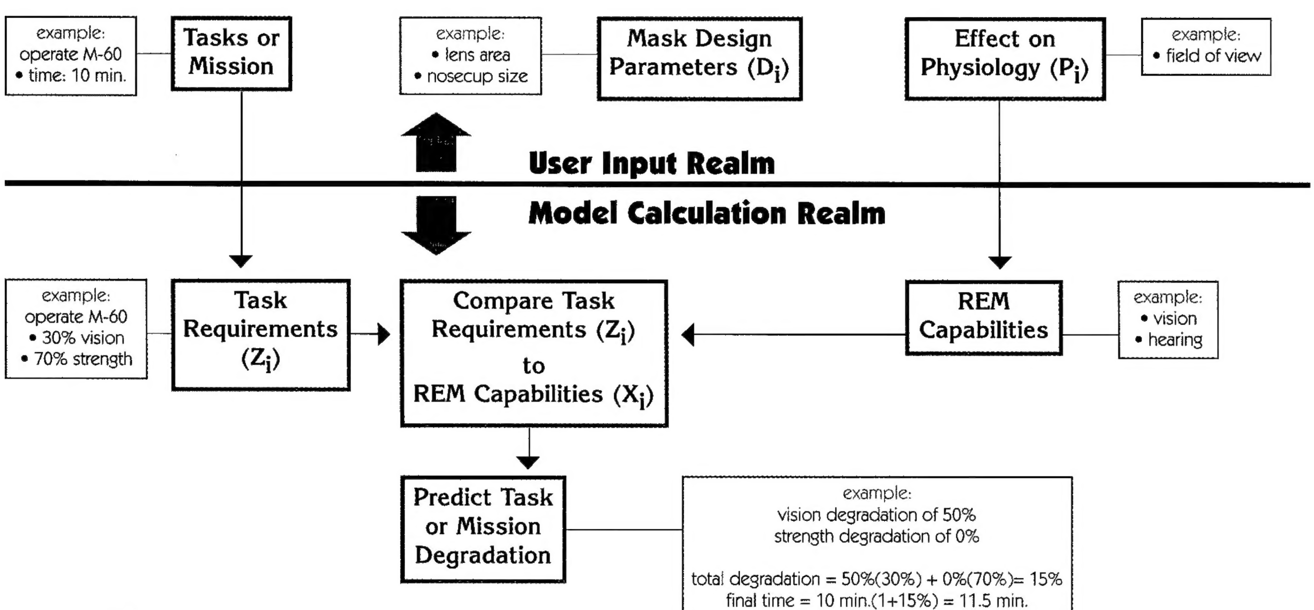

Figure 1. REM model concept and operation.

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